Japanese Patent Application Laid-open No. 5-130070

[Title of the Invention] Spread spectrum communication system

[Abstract]

[Object] An object is to provide a spread spectrum communication system in which a transmitting station can be identified.

[Structure] A control signal section of a packet subjected to primary modulation in a primary modulator 110 is subjected to spread modulation using a common spread code in a multiplier 150. A data section and an error correction of the packet subjected to primary modulation is subjected to spread modulation using a unique spread code in a multiplier 140. A resultant signal is transmitted. As a result, it becomes easy to identify a transmitting communication station. It becomes possible to conduct control or the like effected by the base station, by using one spread code.

[Scope of Claim for a Patent]

[Claim 1] A spread spectrum communication system for conducting spread modulation on a signal subjected to primary modulation by using a spread code and transmitting information between communication terminals,

characterized in that one part of the signal subjected to primary modulation is subjected to spread modulation using a predetermined spread code common to the whole, whereas the other part of the signal subjected to primary modulation is subjected to spread modulation using a spread code unique to

interconnection between communication stations, and the signal thus subjected to spread modulation is transmitted.

[Claim 2] A spread spectrum communication system according to claim 1, characterized in that the one part of the signal is a signal indicating control information for controlling communication, and the other part of the signal is a signal indicating user information to be used by a user to transfer information.

[Claim 3] A spread spectrum communication system according to claim 1, characterized in that the one part of the signal is a signal for conducting broadcast communication, and the other part of the signal is a signal to be used by a communication device to conduct communication individually.

[Detailed Description of the Invention]

[0001]

[Technical Field Pertinent to the Invention] The present invention relates to a spread spectrum communication system for converting an original signal to a signal far broader in band than the original signal.

[0002]

[Prior Art] A spread spectrum scheme is used in some cases because it is excellent in interference resistance and speech secrecy.

[0003] In the spread spectrum communication scheme, there are the direct sequence scheme and the frequency hopping scheme.

[0004] First of all, a communication system using the direct sequence scheme will be described.

[0005] FIG. 11 is a diagram showing the configuration of conventional spread spectrum communication. In FIG. 11, numeral 10 denotes a transmitter, and numeral 20 denotes a receiver.

[0006] In the transmitter 10, a carrier wave is subjected to primary modulation such as PSK (phase shift keying), FM (frequency modulation), or AM (amplitude modulation) with transmission data in a carrier modulation unit 11. Thereafter, a resultant signal is multiplied by a spread code having a bandwidth far broader than transmission data, and thereby subjected to secondary modulation (spread modulation). The spread-modulated signal is amplified in power by a transmission unit 13, and emitted from an antenna 14 as a radio wave.

[0007] On the other hand, in the receiver 20, a high frequency signal input from an antenna 21 is subjected to high frequency amplification, band limiting, and so on in a receiving unit 22, and subjected to spread demodulation in a spread demodulation unit 23. In this spread demodulation, a received signal is multiplied by the same spread code as that of the transmission side. In a carrier demodulation unit 24, the carrier is removed and the data is reproduced.

[0008] FIG. 12 is a diagram showing spectra of a signal at various locations in spread spectrum communication having the configuration shown in FIG. 11.

[0009] As shown in FIG. 12(a) and (b), the spectrum of the signal which has passed through the spread modulation unit 12 becomes far broader than that which has passed through the

carrier modulation unit 11. As a result, the power density per unit frequency significantly falls, and interference on other communication is avoided. If demodulation is performed in the spread demodulation unit 23 of the receiver 20 by using the same spread code as that used in the modulation performed in the transmitter, signal reproduction is possible as shown in FIG. 12(c). If demodulation is performed by using a spread code different from the spread code used in the modulation performed in the transmitter, however, information remains spread and reproduction cannot be reproduced as shown in FIG. 12(d). If signals obtained by modulating a plurality of transmission information pieces with spread codes which are different from each other exist in the same frequency band, therefore, respective information pieces can be reproduced by performing demodulation with the same spread codes as those used at the time of modulation operation of the respective transmission information pieces.

[0010] On the other hand, a spread spectrum communication scheme of a frequency hopping scheme is a scheme of discretely switching carrier frequencies modulated by information pieces in a given band at random and thereby performing spreading in a wide band.

[0011] The above described spread spectrum communication becomes a kind of cryptography. Only in the case where a spread code sequence of the transmitter side coincides with that of the receiver side, it becomes possible to reproduce transmission data. Even if there is a user who acts in violation

such as overpower, therefore, it becomes difficult to identify the violating user. In the case where a base station or the like conducts communication control or maintenance management control, it is necessary for the base station to perform spread modulation with a spread code unique to each of communication stations to be controlled and conduct communication. In addition, it is difficult to perform communication with communication stations differing in spread code by broadcast.

[0012]

[Problems to be Solved by the Invention] As described above, the conventional spread spectrum communication becomes a kind of cryptography. Even if there is a violating user, therefore, it becomes difficult to identify that violating user. It is necessary to perform spread modulation by using a unique spread code possessed by each of communication stations differing in spread code, and conduct communication. In addition, it is difficult to perform communication with communication stations differing in spread code by broadcast. It is desired to solve these problems.

[0013] The present invention has been devised in order to solve such problems. An object of the present invention is to provide a spread spectrum communication system which makes it possible to identify a user using the radio wave and which makes it easy to control the base station.

[0014]

[Means for Solving the Problem] In order to achieve the above

described object, a first invention is a spread spectrum communication system for conducting spread modulation on a signal subjected to primary modulation by using a spread code, and transmitting information between communication stations characterized in that one part of the signal subjected to primary modulation is subjected to spread modulation using a predetermined spread code common to the whole, whereas the other part of the signal subjected to primary modulation is subjected to spread modulation using a spread code unique to interconnection between communication stations, and the signal thus subjected to spread modulation is transmitted. A second invention is a spread spectrum communication system in the first invention, characterized in that one part of the signal is a signal indicating control information for controlling communication, and the other part of the signal is a signal indicating user information to be used by a user to transfer information.

[0015] A third invention is a spread spectrum communication system in the first invention, characterized in that one part of the signal is a signal for conducting broadcast communication, and the other part of the signal is a signal to be used by a communication device to conduct communication individually.

[0016]

[Operation] In a spread spectrum communication system of the present invention, one part of a signal subjected to primary modulation is subjected to spread modulation using a predetermined spread code common to the whole, whereas the other

part of the signal subjected to primary modulation is subjected to spread modulation using a spread code unique to interconnection between communication stations, and the signal thus subjected to spread modulation is transmitted. Therefore, it becomes easy to identify a transmitting communication station, and control and broadcast communication also become easy.

[0017]

[Embodiments] Hereafter, embodiments of the present invention will be described by referring to drawing.

[0018] FIG. 1 is a block diagram showing the configuration of a communication device which is an embodiment in the case where a spread spectrum communication system of the present invention is implemented by using a direct spreading scheme.

[0019] In FIG. 1, numeral 100 denotes a transmitter, 200 a receiver, 300 an antenna for inputting and outputting radio waves, 310 a sharing device for sharing the antenna 300 between the transmitter 100 and the receiver 200, 320 a control unit for conducting the entire control of operation of the communication device, 330 a RAM for storing unique spread codes, 340 a ROM for storing a common spread code, and 350 a clock generator for generating a clock to generate a spread code.

[0020] The transmitter 100 includes a primary modulator 110 for performing primary modulation such as FSK or PSK on data to be transmitted, spread code generators 120 and 130 for generating a spread code, multipliers 140 and 150 for multiplying the spread code generated by the spread code

generators 120 and 130 by a signal modulated by the primary modulator 110, a band pass filter 160 for passing therethrough only a predetermined band of a signal output form the multipliers 140 and 150, and a power amplifier 170 for conducting power amplification on a signal output from the band pass filter 160.

[0021] The receiver 200 includes a high frequency amplifier 210 for conducting high frequency amplification on a received signal fed from the sharing device 310, a band pass filter 220 for passing therethrough only a predetermined band of the signal subjected to the high frequency amplification, correlators 230 and 240 for conducting spread demodulation on the signal subjected to band limiting in the band pass filter 220, and a demodulator 250 for demodulating the signal subjected to spread demodulation in the correlators 230 and 240. The correlators 230 and 240 are programmable correlators such as SAW convolvers.

[0022] FIG. 2 is a diagram showing an example of a spread code of a M sequence having a code length N = 31. In this case, codes of six kinds are obtained. One of them may be used as a common spread code. Five remaining codes are used as unique spread codes.

[0023] Operation of the communication device having the above described configuration will now be described.

[0024] First of all, transmission operation will be described.

[0025] A signal in the packet form is input to the primary modulator 110 of the transmitter 100.

[0026] FIG. 3 is a diagram showing the structure of an example of a packet transmitted by the above described communication device. As shown in FIG. 3, this packet 500 is composed of a control information section 510 for transferring control information such as an ID and a packet length, a data section 520 for transmitting user information to be transmitted, and an error correction section 530 for determining whether there is an error in data.

[0027] The control information section 510 of the packet 500 is subjected to primary modulation in the primary modulator 110, and thereafter input to the multiplier 150. In the ROM 340, data indicating the predetermined common spread code is held. On the basis of this data, the common spread code is generated by the spread code generator 130. In the multiplier 150, the signal supplied from the primary modulator 110 is multiplied by the common spread code. Spread modulation by the common spread code is thus conducted.

[0028] On the other hand, the data section 520 and the error correction section 530 of the packet 500 are subjected to primary modulation in the primary modulator 110, and then input to the multiplier 140. In the RAM 330, data indicating a spread code which is unique to a system cell or interconnection between communication stations is held. This can be changed according to the state. On the basis of the data indicating the spread code which is unique to interconnection between communication stations held in the RAM 330, a spread code which is unique to interconnection between communication stations is generated

by the spread code generator 120. This spread code which is unique to interconnection between the communication stations is multiplied by a signal supplied from the primary modulator 110. Spread modulation using the unique spread code is conducted.

[0029] The signal subjected to the spread modulation in the multipliers 140 and 150 is subjected to band limiting in the band pass filter 160. Thereafter, a resultant signal is amplified in power by the power amplification unit 170. A resultant signal is supplied to the antenna 300 via the sharing device 310 and emitted as a radio wave.

[0030] FIG. 4 is a diagram showing a spectrum of the control information section 510 spread by the common spread code, and a spectrum of the data section 520 and the error correction section 530 spread by the spread code which is unique to interconnection between communication stations.

[0031] Reception operation will now be described.

[0032] A case where the packet 500 is transmitted from another communication device or the like as a radio wave by operation similar to the above described transmission operation will now be described.

[0033] A high frequency signal is induced on the antenna 300 by this radio wave. This high frequency signal is subjected to high frequency amplification in the high frequency amplifier 210, and then subjected to band limiting in the band pass filter 220. The high frequency signal which has passed through the band pass filter 220 is sent to the correlators 230 and 240.

In the correlator 230, correlation is determined on the basis of the data indicating the common spread code stored in the ROM 340. The control information section 510 of the packet 500 is thus subjected to spread demodulation. The control information section 510 subjected to the spread demodulation is subjected to carrier demodulation in the demodulator 250. Control information is thus reproduced and transferred to the control unit 320. On the other hand, correlation is determined in the correlator 240 on the basis of the spread code which is unique to interconnection between communication stations stored in the RAM 330. The data section 520 and the error correction section 530 of the packet 500 are thus subjected to spread demodulation. The data section 520 and the error correction section 530 thus subjected to spread demodulation are subjected to carrier demodulation in the demodulator 250. As a result, the communication data is reproduced.

[0034] In this way, the control information section of the packet 500 is subjected to spread modulation using the common spread code. Therefore, anybody can generate the ID unique to the communication device which is transmitting the radio wave. Furthermore, since data to be communicated has been subjected spread modulation with a spread code which is unique to interconnection between communication stations, speech secrecy of communication is kept.

[0035] In the above described embodiment, the control information section of one packet is subjected to spread modulation with a common spread code, whereas other

sections of the packet are subjected to spread modulation with a spread code unique to interconnection between communication stations. Alternatively, it is also possible to use a control packet as shown in FIG. 5(a) and an information packet as shown in FIG. 5(b). In this case, the control packet is subjected to spread modulation using a spread code unique to a system (communication station) and transmitted, whereas the information packet may be subjected to spread modulation using a common spread code. In such a case, anybody can reproduce the control packet, and consequently it is possible to identify the transmission station. For example, in the case where a base station or the like effects control, it is possible to effect control by using one spread code.

[0036] Furthermore, since the information packet is subjected to spread modulation using a spread code unique to interconnection between communication stations, speech secrecy of communication is kept. By the way, the control packet and the information packet can be transmitted independently.

[0037] FIG. 6 is a diagram showing the configuration of a communication device in the case where the frequency hopping scheme is used. Components conducting the same operations as those of the communication device shown in FIG. 1 are denoted by like numerals, and duplicated description thereof will be omitted.

[0038] In the communication device of this embodiment, an oscillation frequency of a variable frequency synthesizer 360

is changed on the basis of data indicating a unique spread code held in the RAM 330 or data indicating a common spread code held in the ROM 340. An output signal of the variable frequency synthesizer 360 is supplied to spread modulators 180 and 190 of a transmitter 100a, and spread modulation of the frequency hopping scheme is conducted. An output signal of the variable frequency synthesizer 360 is supplied to spread demodulators 260 and 280 of a receiver 200a, and spread demodulation of the frequency hopping scheme is conducted. By the way, synchronizing circuits 270 and 290 are circuits for synchronizing hopping of the output signal of the band pass filter 220 with hopping of the output signal of the variable frequency synthesizer 360.

[0039] Operation of transmitting the packet 500 shown in FIG. 3 from the communication device having the above described configuration will now be described.

[0040] First, when transmitting the packet 500, the control information section 510 of the packet 500 is subjected to primary modulation in the primary modulator 110, and this signal is transferred to a spread modulator 180. On the other hand, the variable frequency synthesizer 360 successively generates oscillation signals each having a frequency based upon data indicating a common spread code held in the ROM 340 and supplies the oscillation signals to the spread modulator 180. In the spread modulator 180, spread modulation of the frequency hopping scheme is conducted. If the data section 520 and the error correction section 530 of the packet 500 are subjected

to primary modulation in the primary modulator 110, this signal is transferred to the spread modulator 190. On the other hand, the variable frequency synthesizer 360 successively generates oscillation signals each having a frequency based upon data indicating a unique spread code held in the RAM 330 this time and supplies the oscillation signals to the spread modulator 190. In the spread modulator 190, spread modulation of the frequency hopping scheme is conducted.

[0041] When receiving the packet 500 shown in FIG. 3, the control information section 510 is subjected to spread demodulation in the spread demodulator 280, the data section 520 and the error correction section 530 are subjected to spread demodulation in the spread demodulator 260.

[0042] In this embodiment as well, it is possible to use the information packet and the control packet shown in FIG. 4 in the same way as the embodiment shown in FIG. 1, conduct spread modulation on the information packet by using a unique spread code, and conduct spread modulation on the control packet by using a common spread code.

[0043] FIG. 7 is a diagram showing a negotiation procedure of spread codes in CDMA (CODE DIVISION MULTIPLE ACCESS). Numeral 700 denotes a communication device, and numeral 710 denotes a base station.

[0044] First, the communication device 700 requests a spread code from the base station 710 by using a control packet 720. Thereupon, the base station 710 assigns a spread code to the communication device 700 by using a control packet 730.

Thereafter, the communication device 700 executes data transmission. By doing so, the spread code can be used efficiently, and the multiplex level can be increased. For example, in the case where the bit error rate is raised and the transmission quality is lowered by cross correlation characteristic of the spread codes, it is possible to alter the spread code even in the middle course of communication by using the control packet.

[0045] FIG. 8 is a diagram showing the case where transmission output control is effected from the base station to the mobile station in order to solve the distance problem. As illustrated, the base station 710 transmits a control packet 760 subjected to spread modulation using a common spread code to the base station 750. According to output control information carried by the control packet 760, the mobile station 750 alters transmission power. In this case, the base station 710 can also request transmission output control from each mobile station individually. Furthermore, it can also be implemented for the mobile station to request the base station to conduct the transmission output control.

[0046] FIG. 9 is a diagram showing the case where a violating station is identified.

[0047] In FIG. 9, numeral 800 denotes a violating mobile station, numeral 810 denotes an administrating station. It is now assumed that the violating mobile station 800 is transmitting a control packet 820 subjected to spread modulation using a common spread code and an information

packet 830 subjected to spread modulation using a unique spread code. In this case, the administrating station 810 can reproduce an ID of the control packet 820 transmitted by the violating mobile station 800 by using a common spread code correlator 811 and thereby identify the violating mobile station 800.

[0048] FIG. 10 is a diagram showing base station switchover at the time of fault occurrence.

[0049] Normally, a base station 900 covers a zone A where communication is conducted by using a unique spread code A, and a base station 910 covers a zone B where communication is conducted by using a unique spread code B. When a fault has occurred in the base station 900, it is possible to transmit a control packet 930 subjected to spread modulation using the common spread code to mobile stations 920 and 921 in the zone A, inform the mobile stations 920 and 921 of the unique spread code B, and thereby instruct the mobile stations 920 and 921 to switch over the base station. FIG. 13 is a block diagram showing the configuration of a communication device which is an embodiment of the case where a spread code common to broadcast communication implemented by using the direct spread scheme is used. FIG. 14 is a block diagram showing the configuration of a communication device which is an embodiment of the case where a spread code common to broadcast communication implemented by using the frequency hopping scheme is used. The present embodiment is effective to the case where information communicated by broadcast is subjected to spread modulation

by using a common spread code no matter whether information is control information or user information. The present embodiment is effective especially to the case where simultaneous communication with a plurality of communication stations is conducted as in the above described base station control at the time of fault occurrence.

[0050] In the above described embodiment, therefore, it becomes possible to identify a station which is transmitting a signal by transmitting a signal subjected to spread modulation using a common spread code in part. It becomes possible to conduct control or the like effected by the base station, by using one spread code.

[0051]

[Effect of the Invention] In the spread spectrum communication system of the present invention, one part of a signal subjected to primary modulation is subjected to spread modulation using a predetermined spread code common to the whole, whereas the other part of the signal subjected to primary modulation is subjected to spread modulation using a spread code unique to interconnection between communication stations, and the signal thus subjected to spread modulation is transmitted. As a result, it becomes easy to identify a transmitting communication station. It becomes possible to conduct control or the like effected by the base station, by using one spread code.

[Brief Description of the Drawing]

[FIG. 1] A block diagram showing the configuration of a

communication device which is an embodiment in the case where a spread spectrum communication system of the present invention is implemented by using a direct spread scheme.

[FIG. 2] A diagram showing an example of a spread code of a M sequence having a code length N = 31.

[FIG. 3] A diagram showing the structure of an example of a packet transmitted by a communication device.

[FIG. 4] A diagram showing a spectrum of a control information section spread by using a common spread code and a spectrum of a data section and an error correction section spread by using a spread code unique to interconnection between communication devices.

[FIG. 5] A diagram showing the case where a control packet (FIG. 5(a)) and an information packet (FIG. 5(b)) are used, and the control packet is subjected to spread modulation using a spread code unique to a system (communication device) and transmitted, and the information packet is subjected to spread modulation using a common spread code.

[FIG. 6] A diagram showing the configuration of a communication device in the case where a frequency hopping scheme is used.

[FIG. 7] A diagram showing a negotiation procedure of spread codes in the CDMA.

[FIG. 8] A diagram showing the case where transmission output control is requested from a mobile station by a base station.

[FIG. 9] A diagram showing the case where a violating station is identified.

[FIG. 10] A diagram showing switchover of a base station

conducted at the time of occurrence of a fault.

[FIG. 11] A diagram showing the configuration of conventional spectrum spread communication.

[FIG. 12] A diagram showing spectra of signals at various locations in spread spectrum communication of a configuration shown in FIG. 11.

[FIG. 13] A diagram showing the direct sequence scheme of a spread spectrum communication system conducting broadcast communication.

[FIG. 14] A block diagram showing the configuration of a communication device which is an embodiment of the case where a spread spectrum communication system conducting broadcast communication is implemented by using a frequency hopping scheme.

[Description of reference numerals]

100... transmitter

110... primary modulator

120, 130... spread code generator

140, 150... multiplier

160, 220... band pass filter

170... power amplifier

200... receiver

210... high frequency amplifier

230, 240... correlator

250... demodulator

300... antenna

310... sharing device

320... control unit

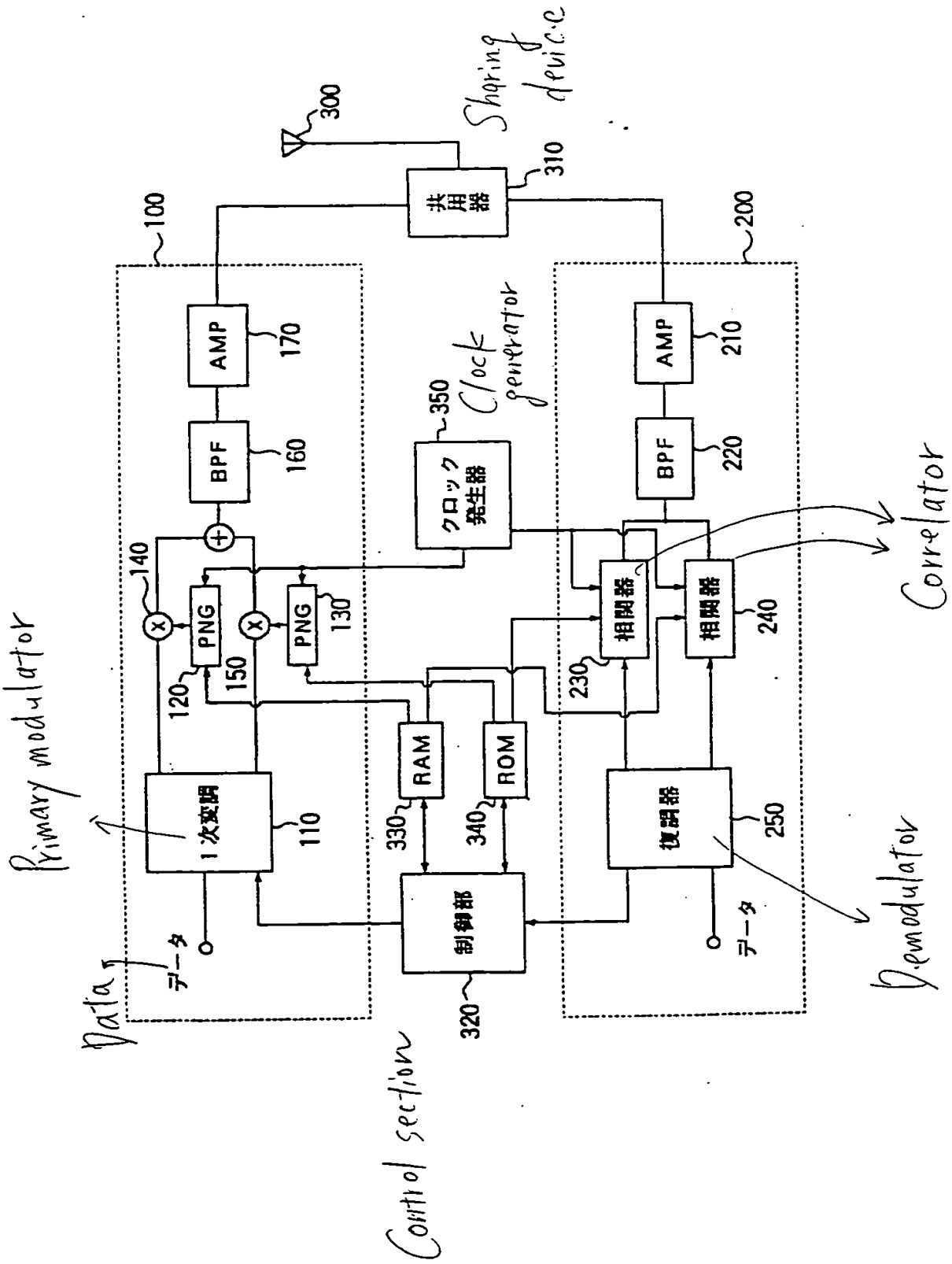
330... RAM

340... ROM

350... clock generator

FIG. 1

【図1】


300
共用器
310
Sharing device
100
200
AMP
170
AMP
210
BPF
160
BPF
220
350
クロック発生器
Clock generator
140
PNG
130
PNG
150
120
230
相関器
相関器
240
Correlator
RAM
330
ROM
340
1次変調
110
復調器
250
制御部
320
データ
データ
Primary modulator
Demodulator
Control section
Data

Control code Common

1 1 1 1 1 0 0 1 1 0 1 0 0 1 0 0 0 0 1 0 1 0 1 1 1 0 1 1 0 1 1 0 0 0 制御符号 共通

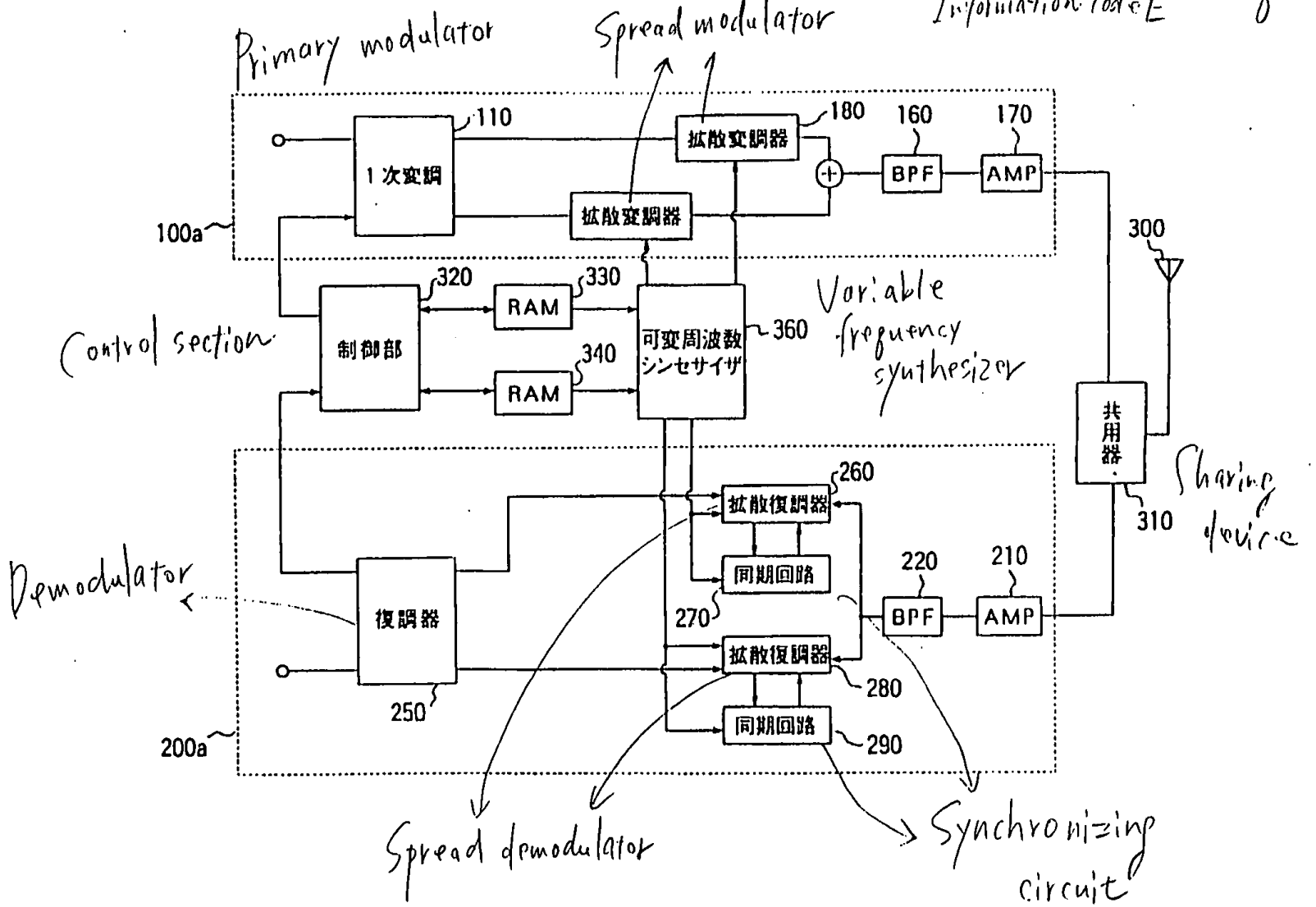
1 1 1 1 1 0 0 1 0 0 1 1 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 0 1 1 1 0 情報符号A 固有 Unique

Information code A

1 1 1 1 1 0 1 1 0 0 1 1 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 0 1 0 情報符号E 固有 Unique

Information code E

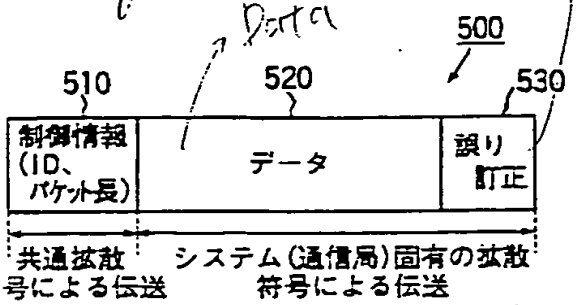
【図2】 FIG. 2



【図6】 FIG. 6

Control information (ID, packet length)

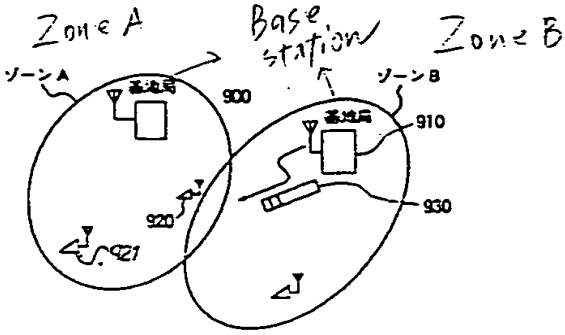
【図3】FIG. 3



Error correction

FIG. 10

【図10】

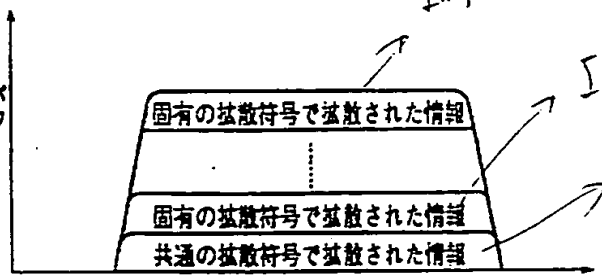


Transmission using common spread code

Transmission using common spread code & unique to system (communication station)

【図4】

FIG. 4



Power

Spectrum

Frequency

Information spread by using unique spread code

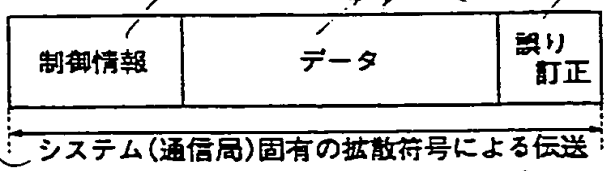
Information spread by using unique spread code

Information spread by using common spread code

Transmission using spread code unique to system (communication station)

【図5】

FIG. 5

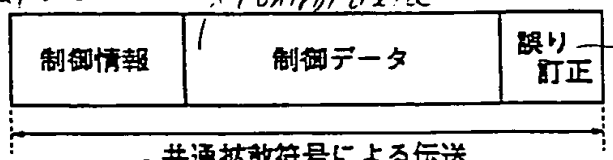


Control information

Data

Error correction

(a) 情報パケット Information packet



Control information

Control data

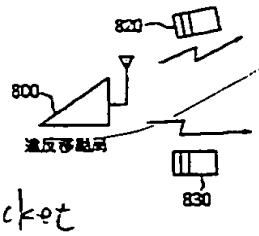
Error correction

(b) 制御パケット Control packet

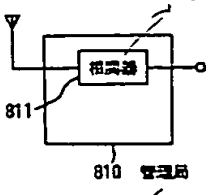
Transmission using common spreadcode

FIG. 9

【図9】



Violating mobile station



Correlator

Administrating station

FIG. 7
【図7】

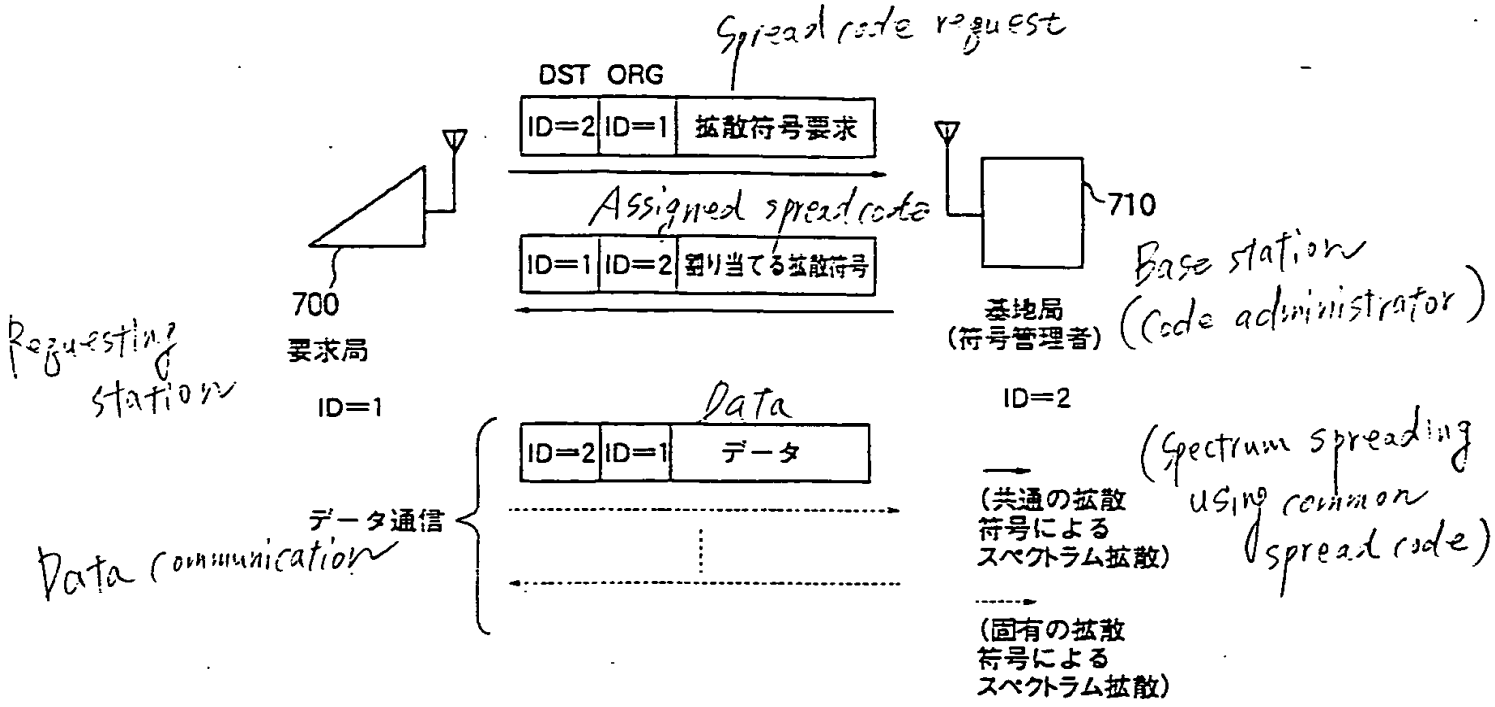
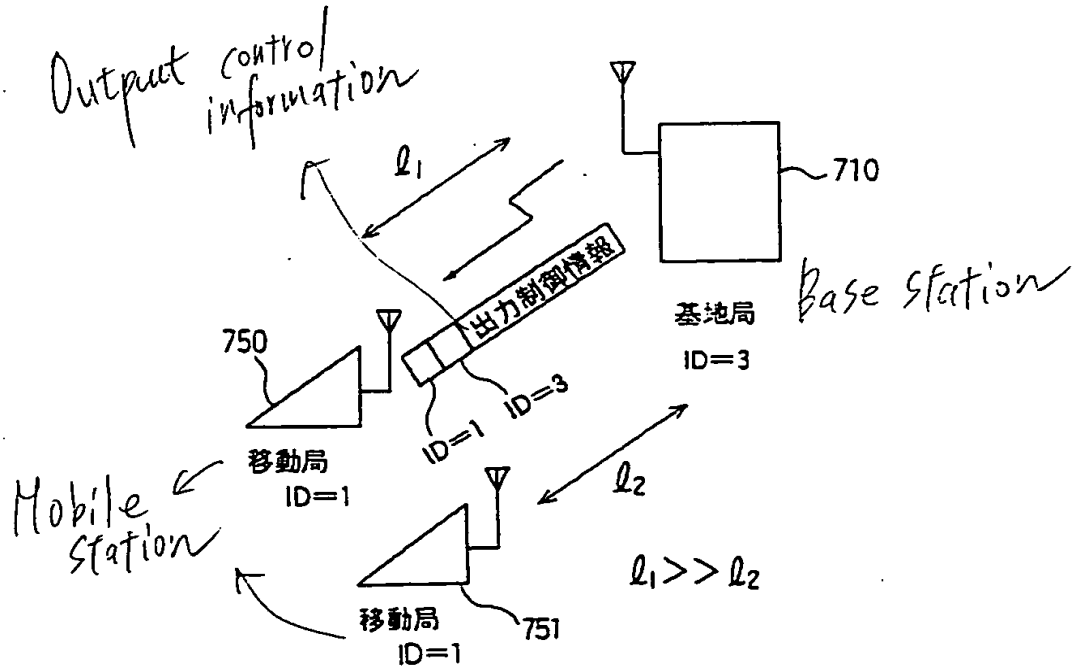
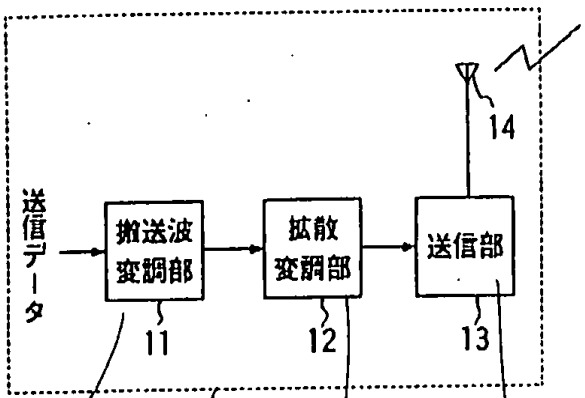


FIG. 8
【図8】



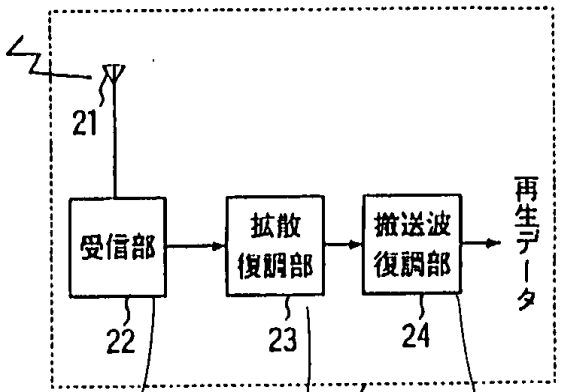


Transmission data

Carrier modulation unit

Spread modulation unit

Transmission unit



Reproduced data

Reception unit

Spread demodulation unit

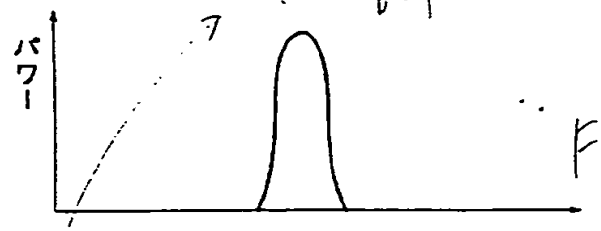
Carrier demodulation unit

図11
FIG. 11

F図.12

【図１２】

Spectrum of transmission information before frequency spreading.

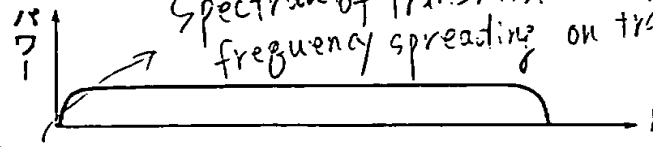


Power

Frequency

(a) 周波数拡散前の送信情報のスペクトラム

Spectrum of transmission information after frequency spreading on transmission side

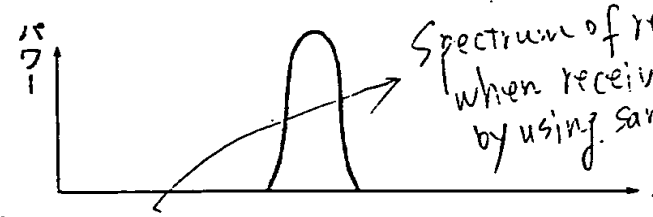


Power

Frequency

(b) 送信側の周波数拡散後の送信情報のスペクトラム

Spectrum of received information obtained when received information is demodulated by using same spread code as that of transmission modulation on reception side



Power

Frequency

(c) 受信側で送信の変調と同一の拡散符号で復調したときの受信情報のスペクトラム

Power

Frequency

(d) 受信側で送信の変調とは異なる拡散符号で変調しようとしたばあいのスペクトラム

Spectrum obtained when it is attempted to modulate received information by using spread code different from that of transmission modulation on reception side

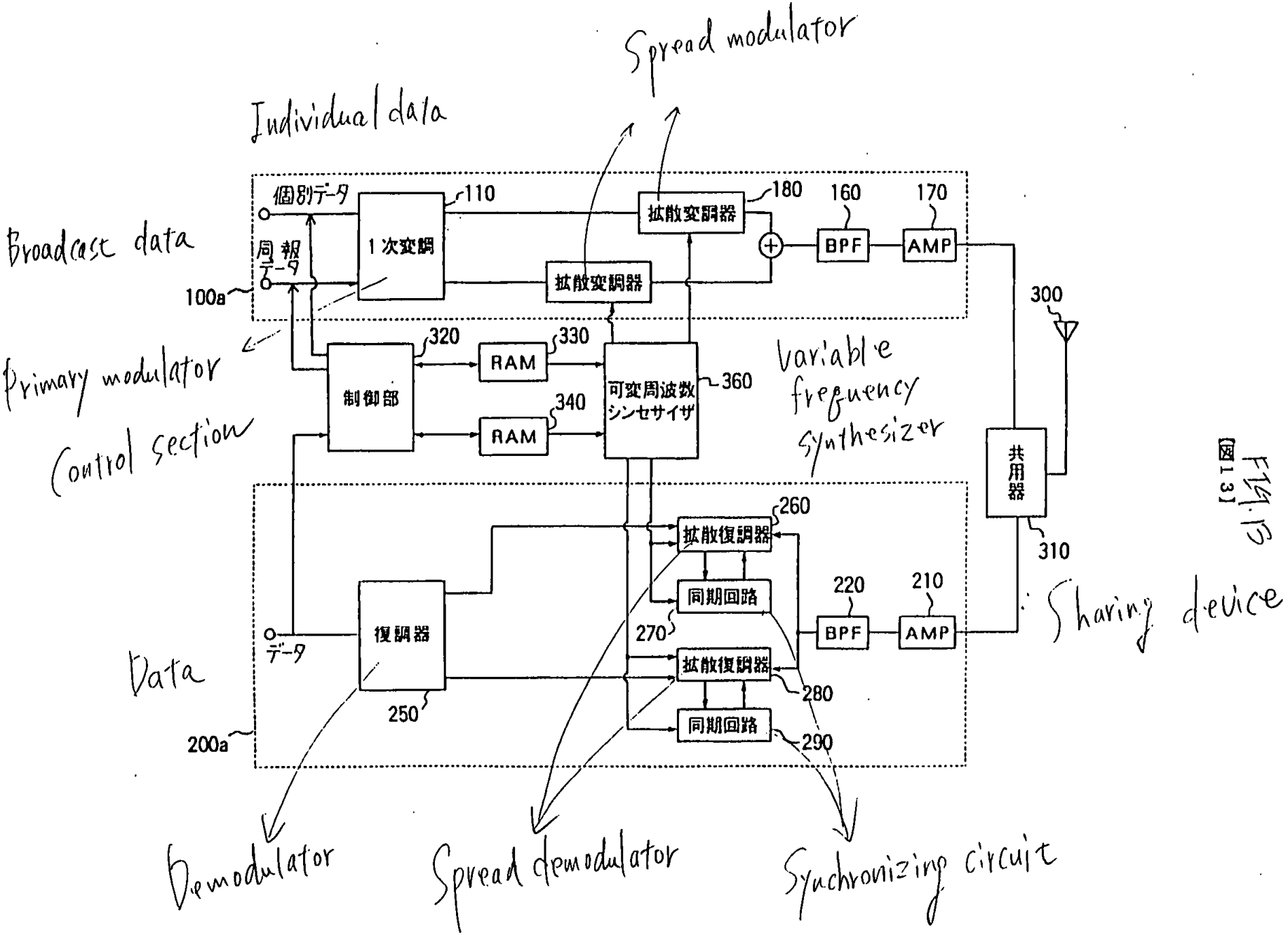
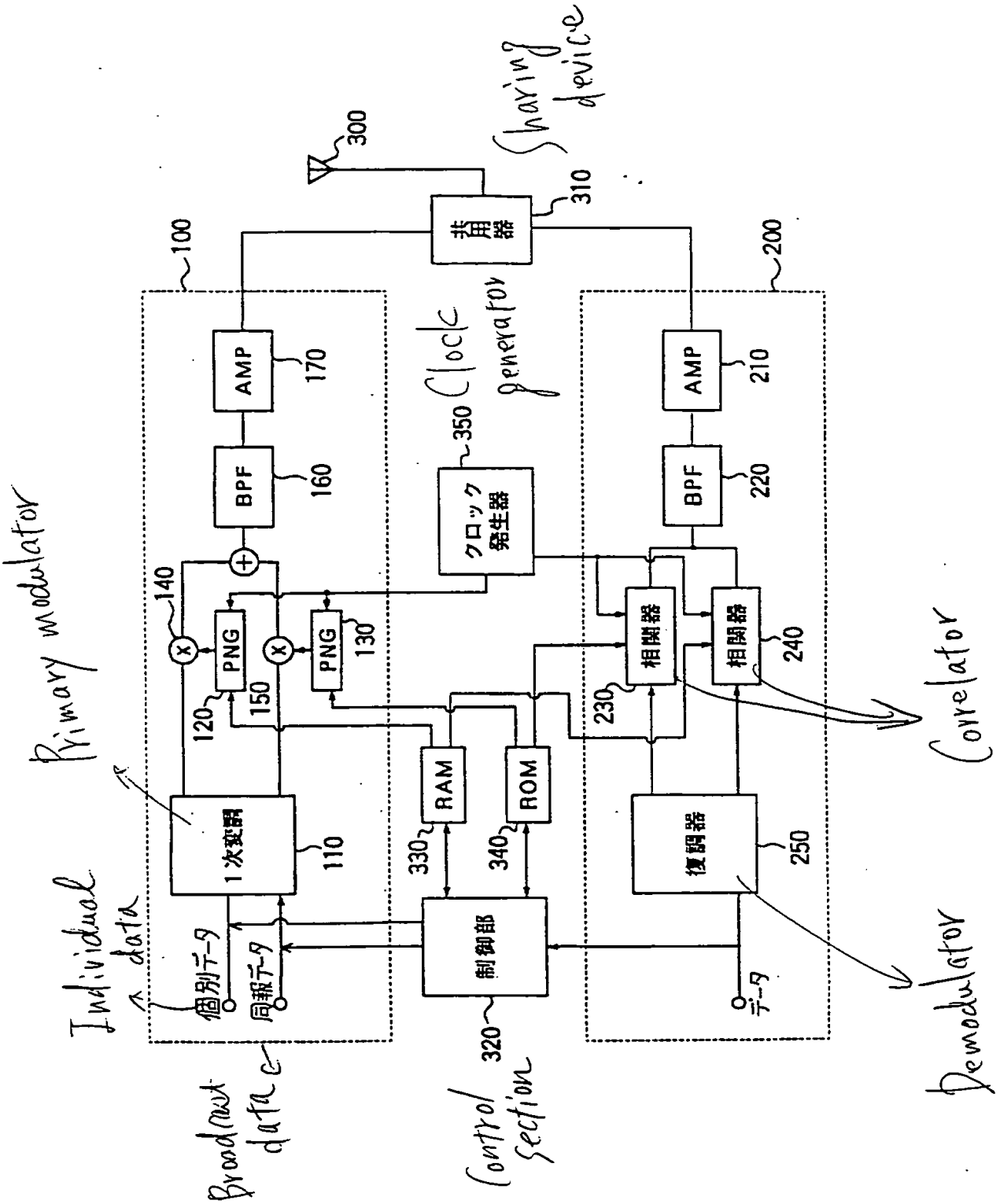

Spread modulator
Individual data
個別データ
110
拡散変調器
180
160
170
Broadcast data
同報データ
1次変調
BPF
AMP
100a
拡散変調器
300
320
330
RAM
制御部
可変周波数シンセサイザ
360
Primary modulator
Variable frequency synthesizer
Control section
340
RAM
共用器
260
拡散復調器
同期回路
220
210
310
Sharing device
270
BPF
AMP
データ
復調器
拡散復調器
Data
280
250
同期回路
290
200a
Demodulator
Spread demodulator
Synchronizing circuit

FIG. 13
【図13】

FIG. 14

【図14】


100
200
300
310
共用器
AMP
170
210
BPF
160
220
クロック発生器
350
140
PNG
130
150
120
相関器
230
240
1次変調
110
RAM
330
ROM
340
制御部
320
復調器
250
個別データ
同報データ
データ
Primary modulator
Individual data
Broadcast data
Control section
Clock generator
Sharing device
Correlator
Demodulator